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Study of the neutron damage on electronics at the National Ignition Facility

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National Ignition Campaign

Study of the neutron damage on electronics at the National Ignition Facility

**19th Topical Meeting on the Technology of Fusion Energy
November 10, 2010**

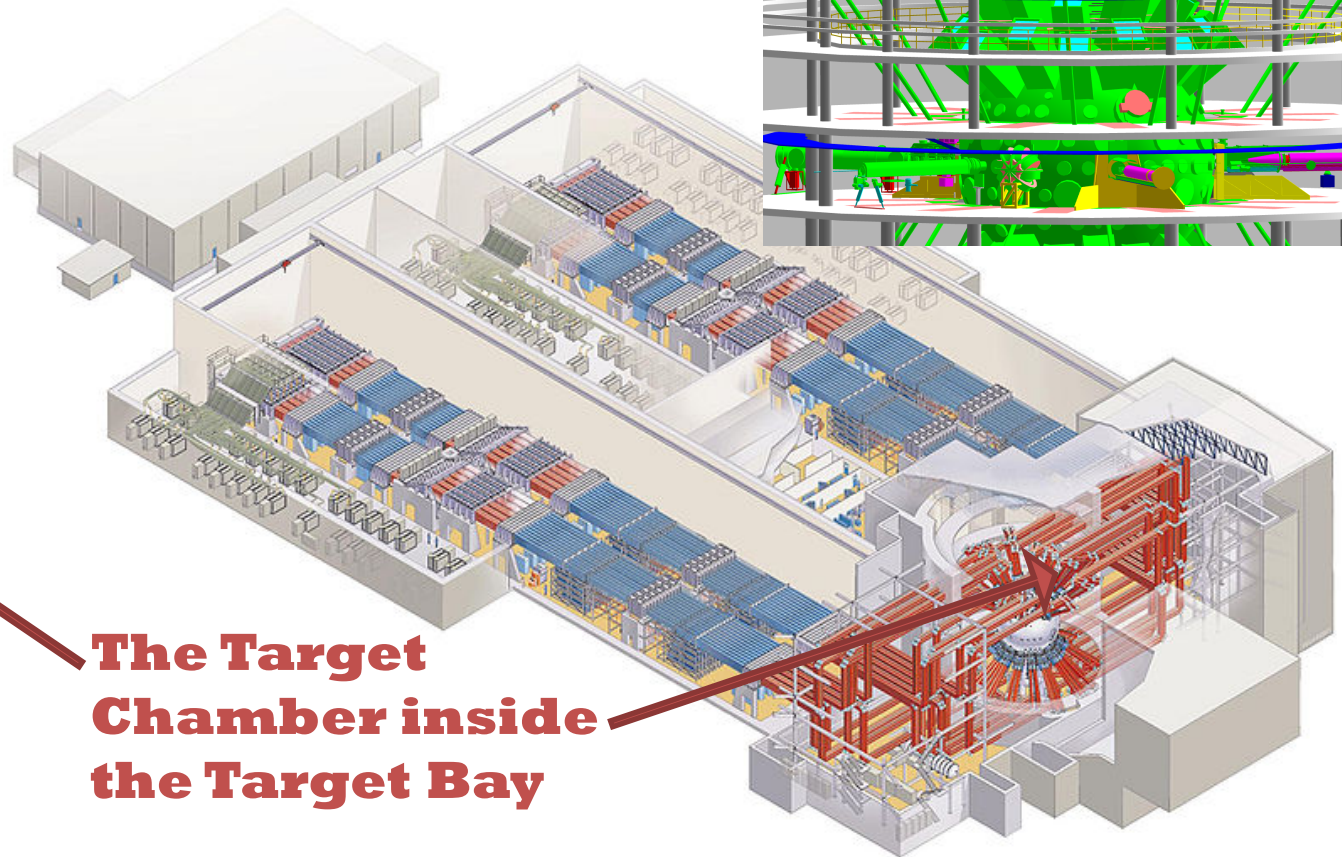
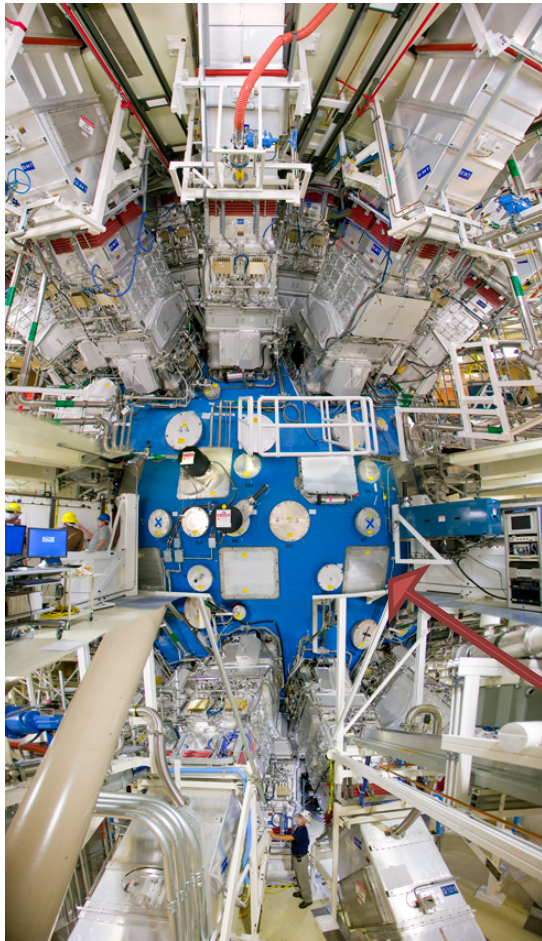


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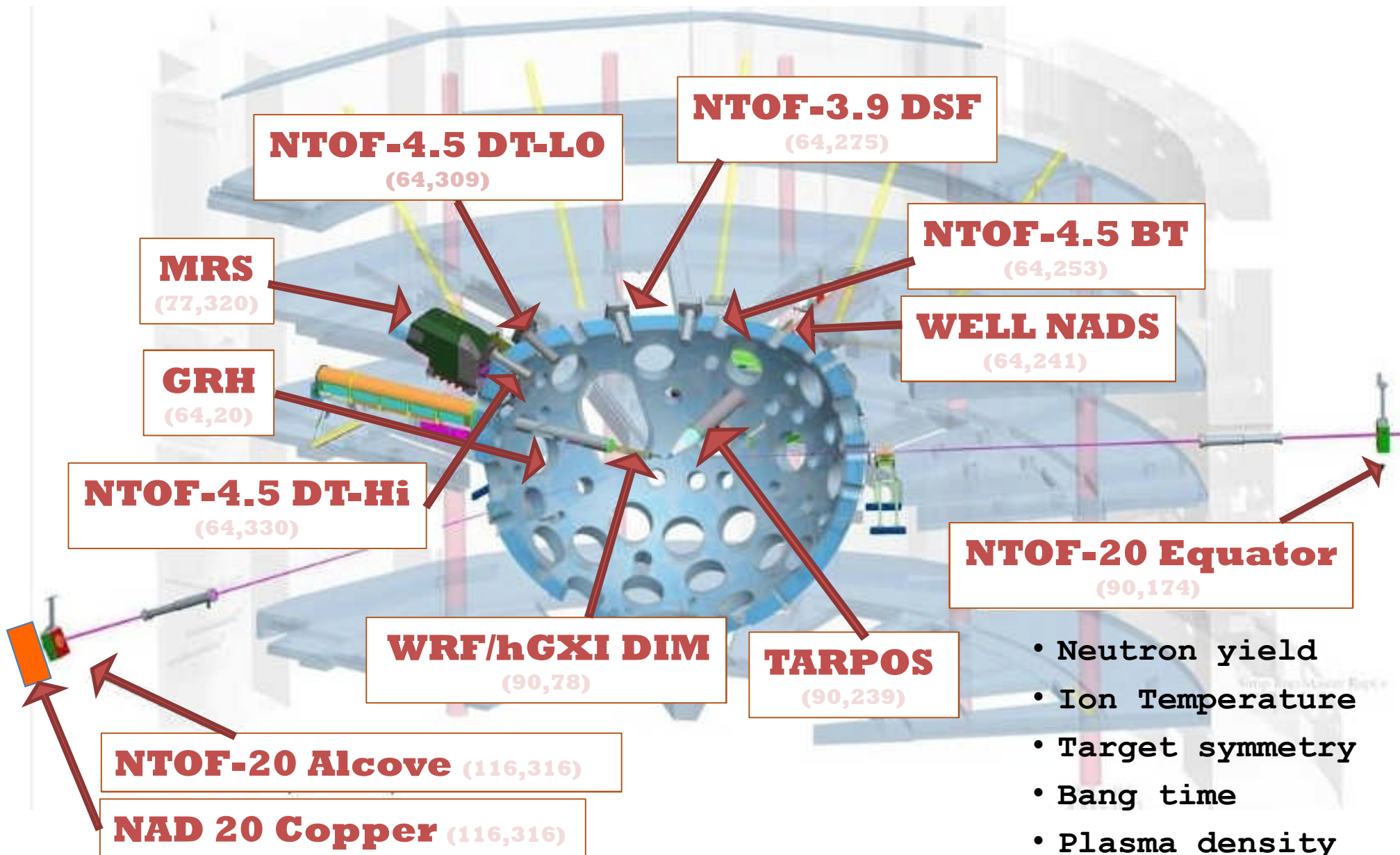
The National Ignition Facility



The Target Chamber inside the Target Bay

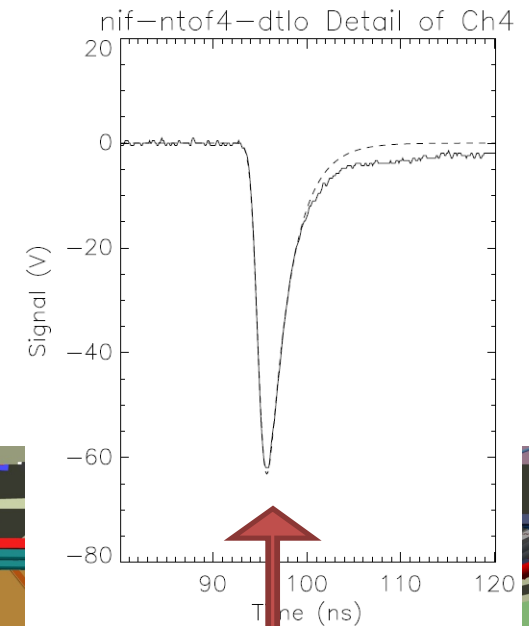
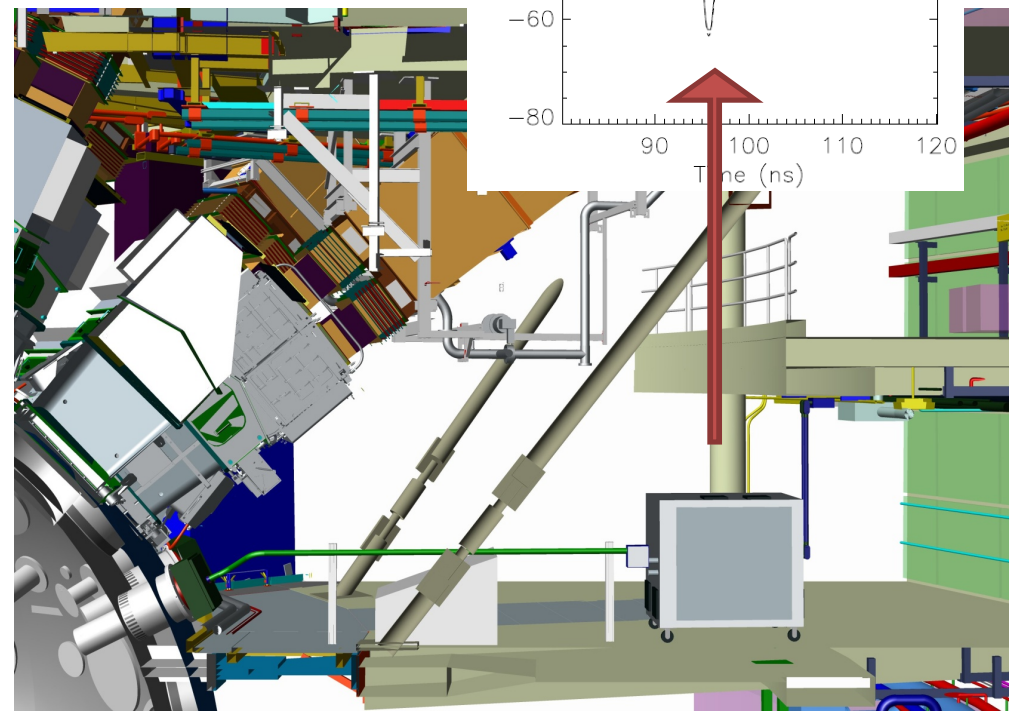
- The most powerful laser in the world
- 192 laser beams focus on a mm-size Deuterium Tritium target
- Goal: obtain ignition fusion
- How to monitor a shot: diagnostics

Nuclear Diagnostics to monitor a shot

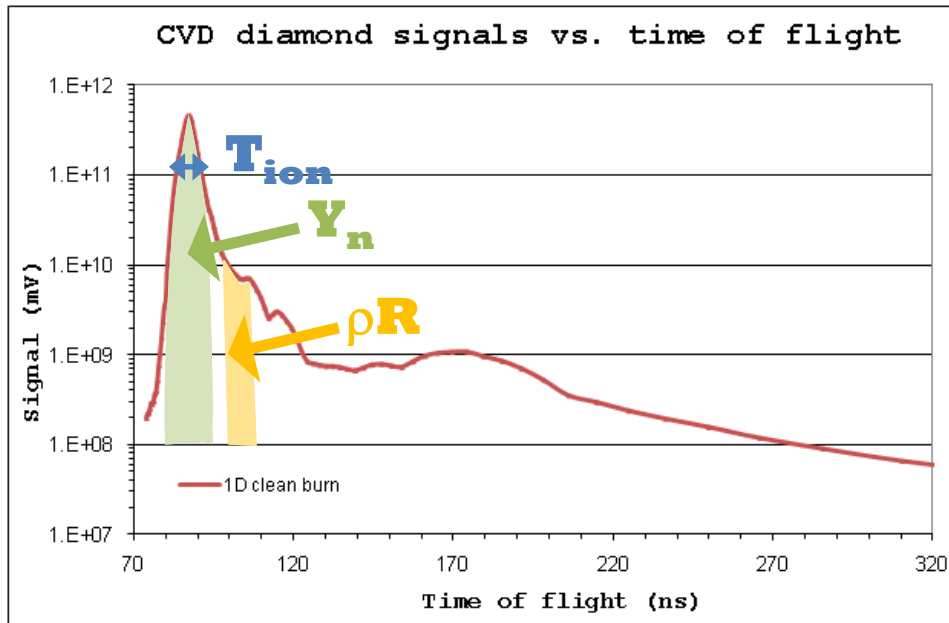


Neutron time-of-flight diagnostic at 4.5m from TCC

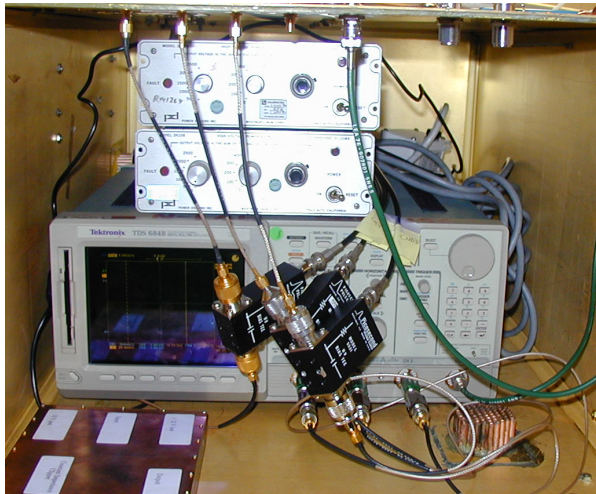
- Scintillators and CVD diamonds
- Will measure neutron yield & ion temperature
- May measure the areal density of the plasma
- Will be used for neutron yields up to $1e16$



Neutron time-of-flight diagnostic

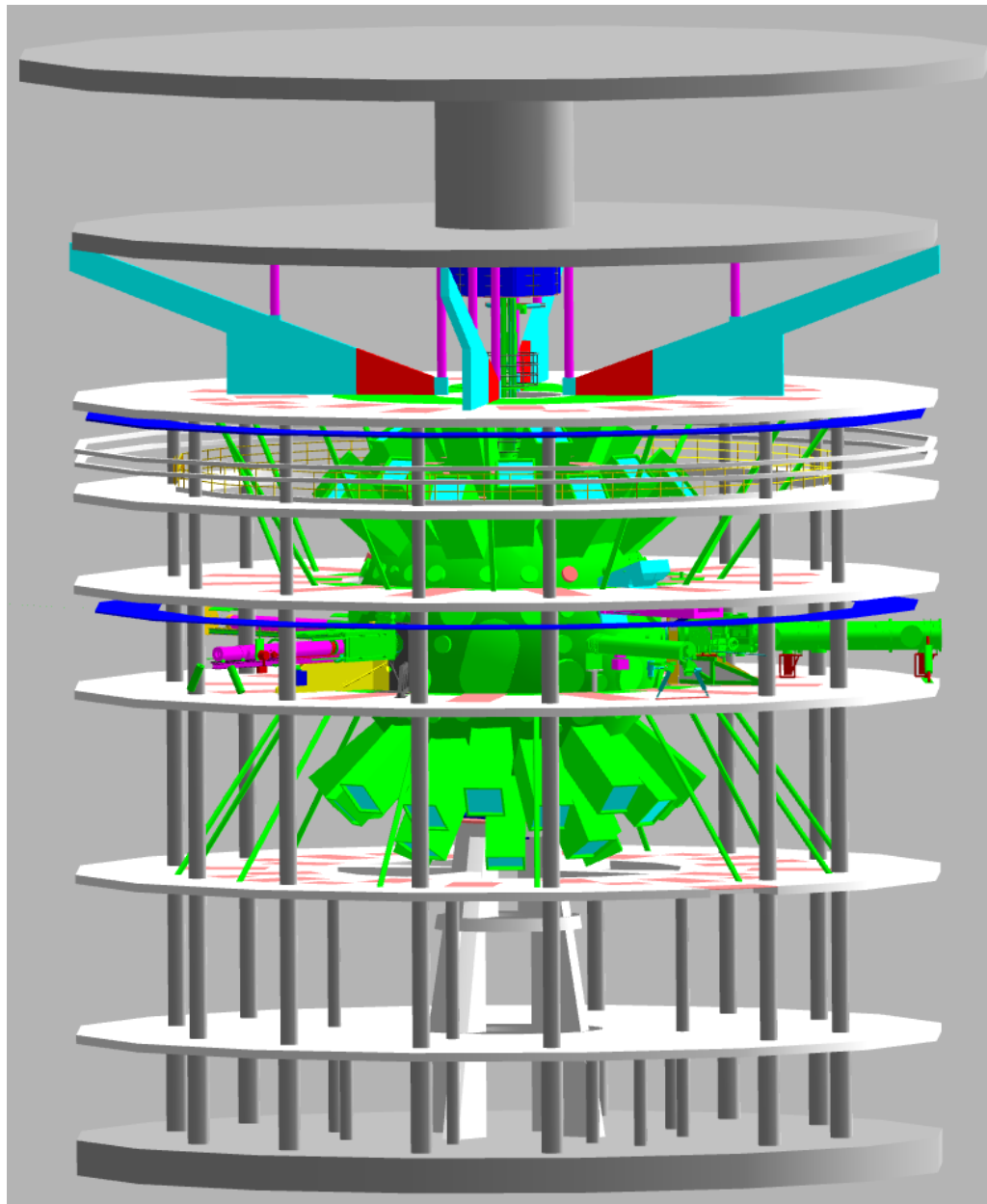


- Neutron yield (Y_n) \propto integral under the 14.1 MeV pulse
- Ion temperature (T_{ion}) \propto 14.1 MeV pulse width
- Plasma areal density (ρR) \propto integral under the 10-12 MeV signal

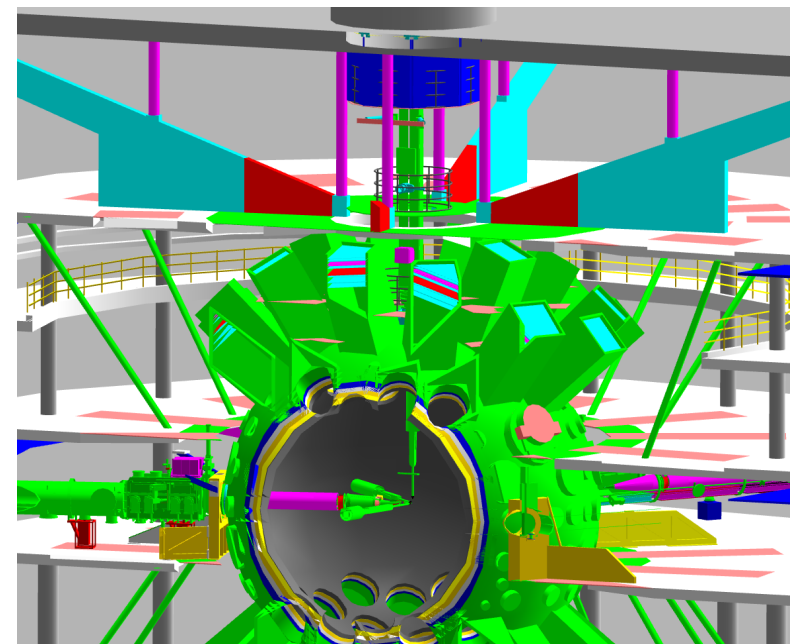


- Previous experience showed that damage starts at $\approx 1e7 \text{ n/cm}^2$
- Neutron Damage leads to:
 - Noise \rightarrow added signal
 - Spikes
 - Stars
 - Loss of data or instrument

Simulation of the radiation background



- The Monte Carlo code MCNP was used
- Calculation of neutron and gamma fluxes per energy bin
- Use of different shields: concrete and polyethylene

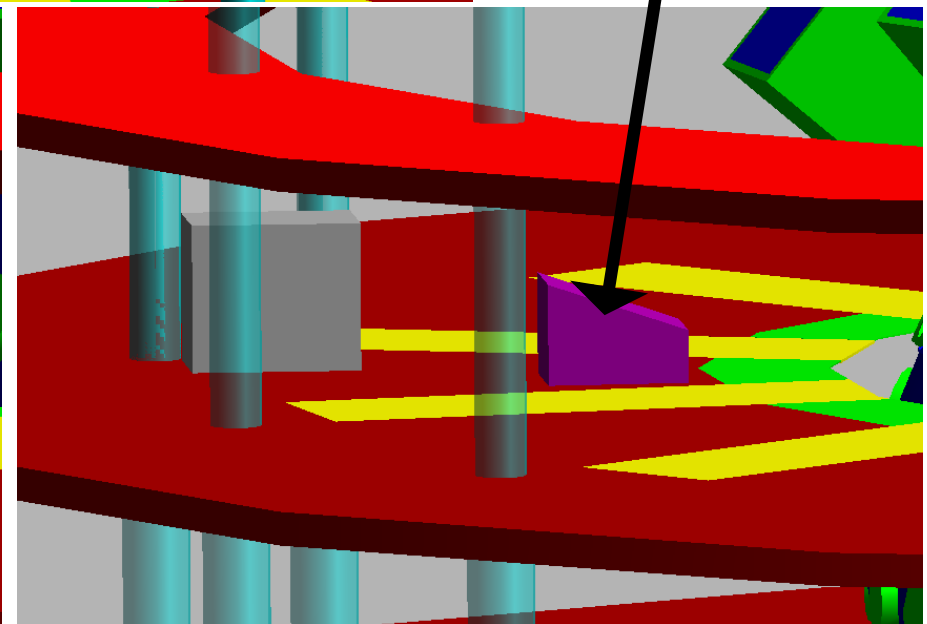
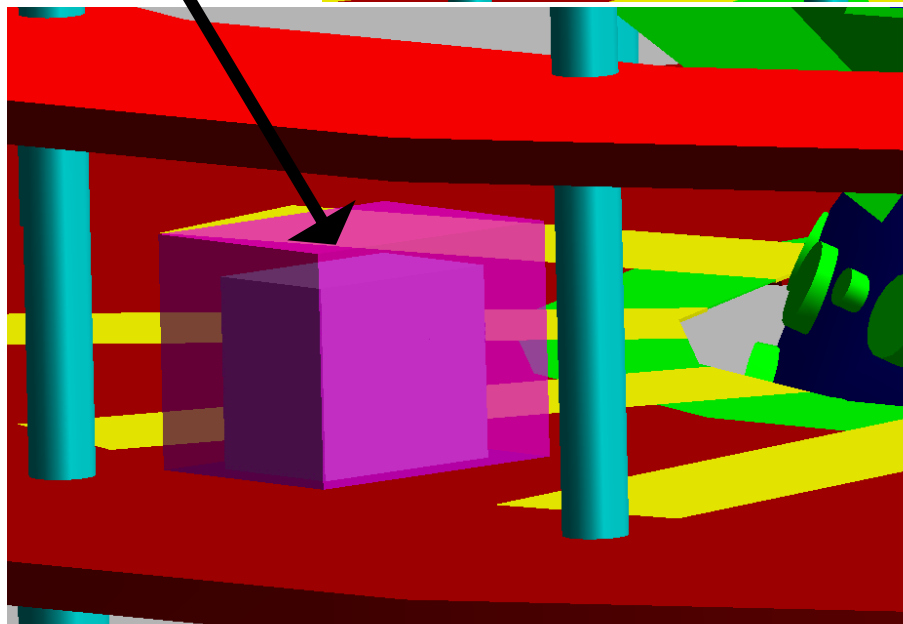


Simulation of the radiation background

30cm of
polyethylene
on all side
but the
bottom side

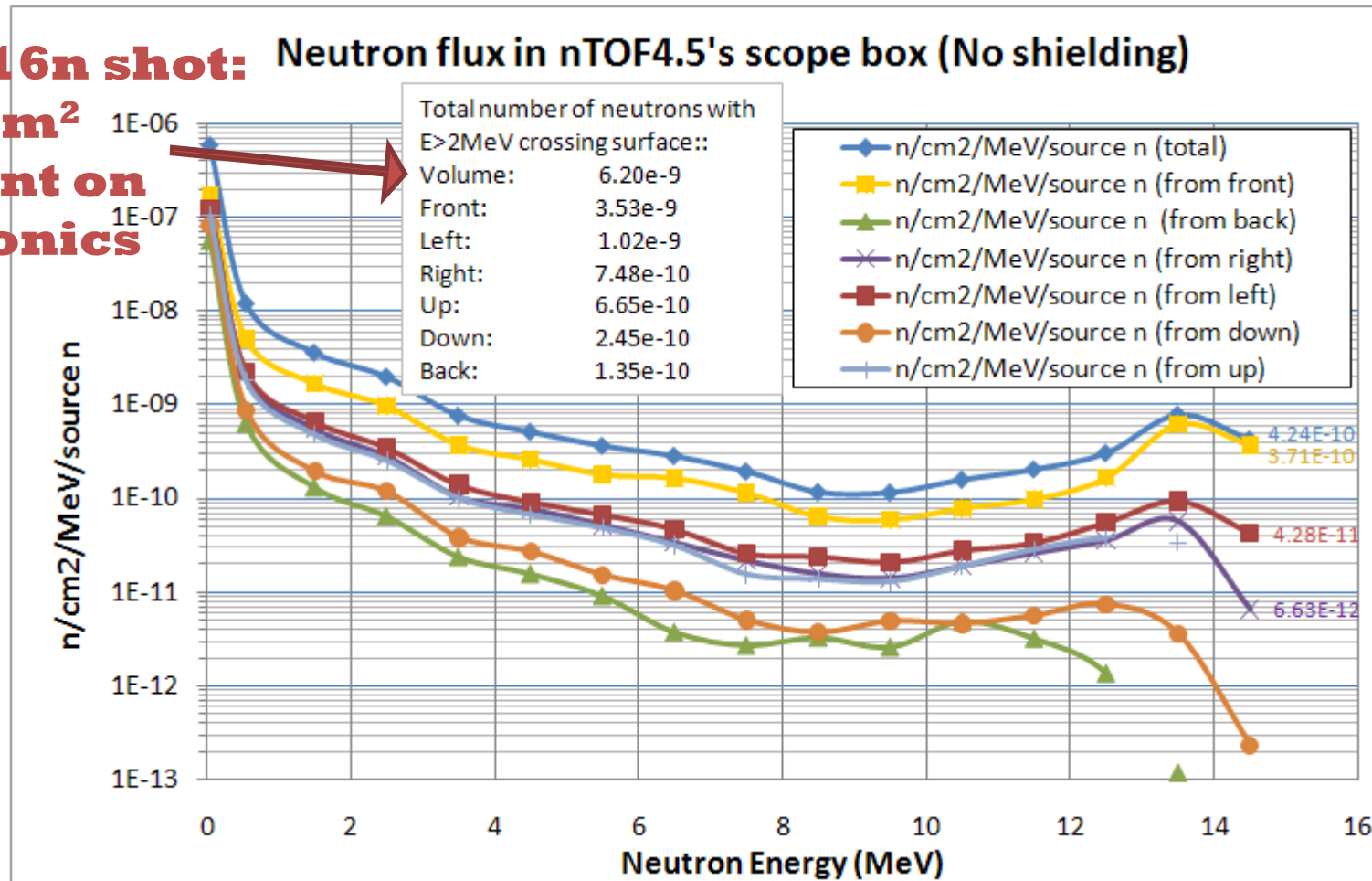
Cart with
electronics
inside

~1.5m of
concrete



Results **w/o** concrete: neutrons flux in box with angular distribution

**For 1e16n shot:
6e7n/cm²
incident on
electronics**

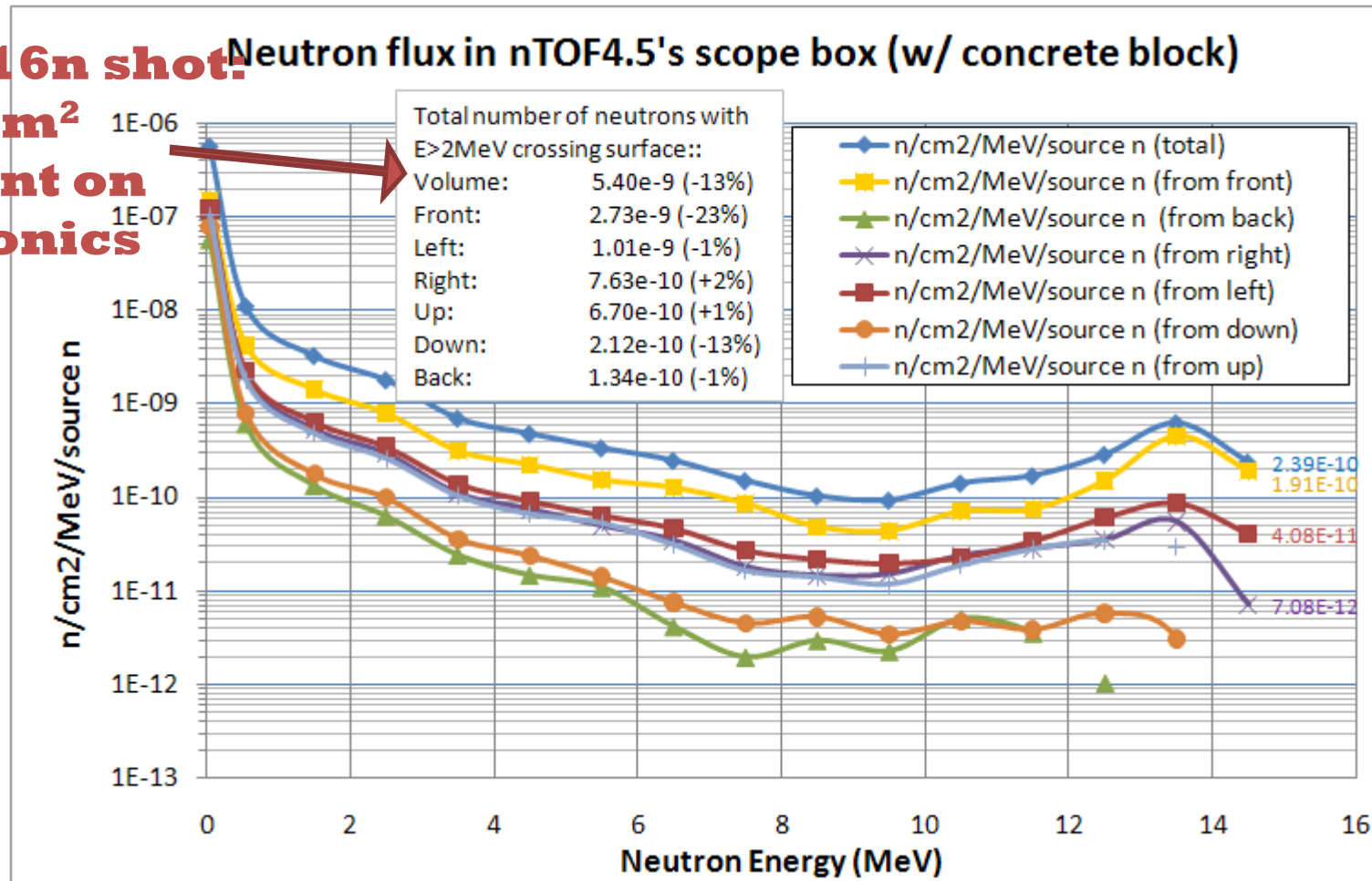


- Number of neutrons crossing the front surface \approx number of neutrons crossing sides and up surfaces
- The majority of neutrons with energies close to 14.1 MeV are not primary but are scattered with small angles

**Lots of
scattering!**

Results w/ concrete: neutrons flux in box with angular distribution

**For 1e16n shot:
5e7n/cm²
incident on
electronics**

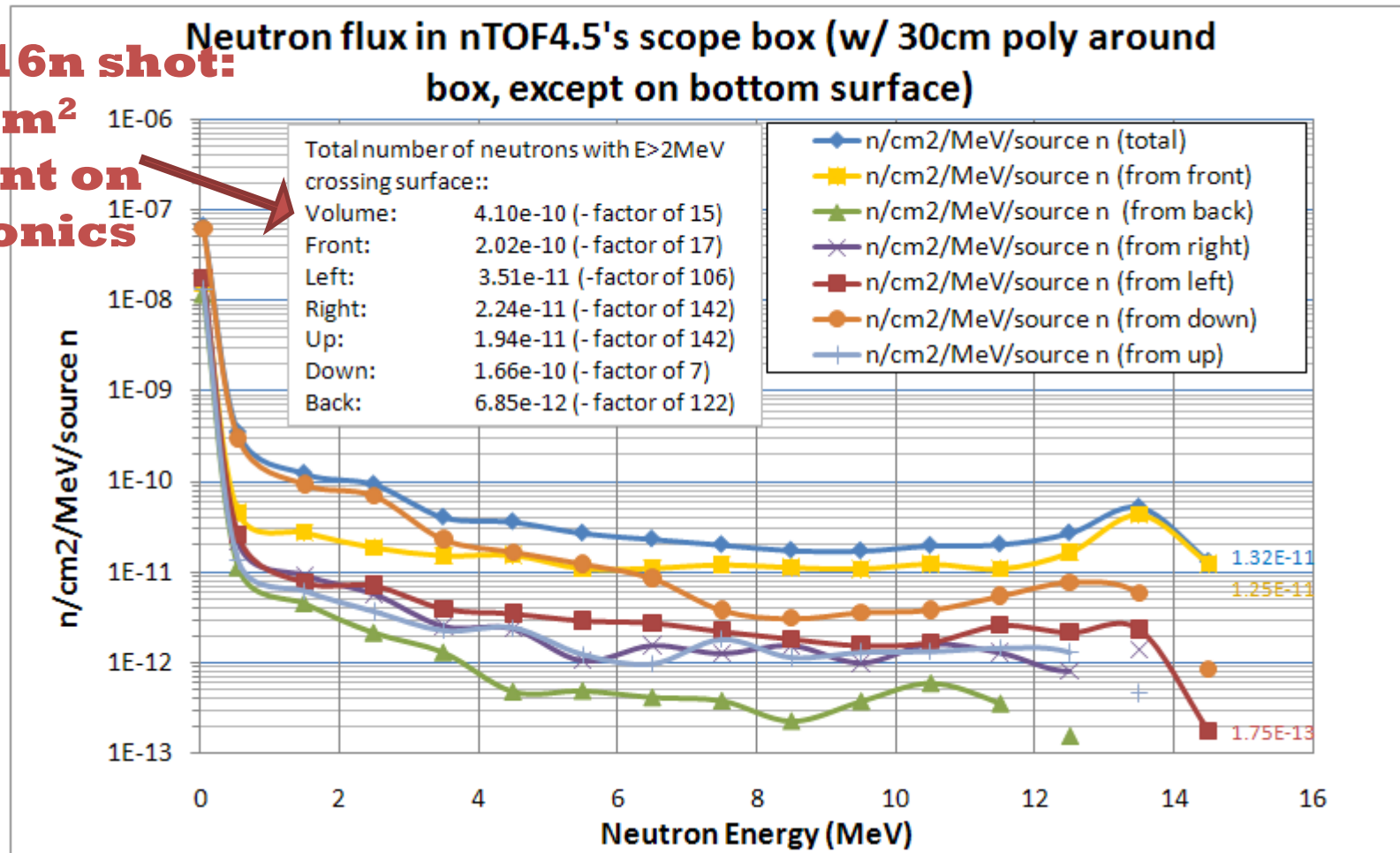


- Concrete shield reduces only by 13% the number of neutrons
- Rule of thumb: factor of 10 reduction per foot of concrete → should be 10^4 in this case!!

**Lots of
scattering!**

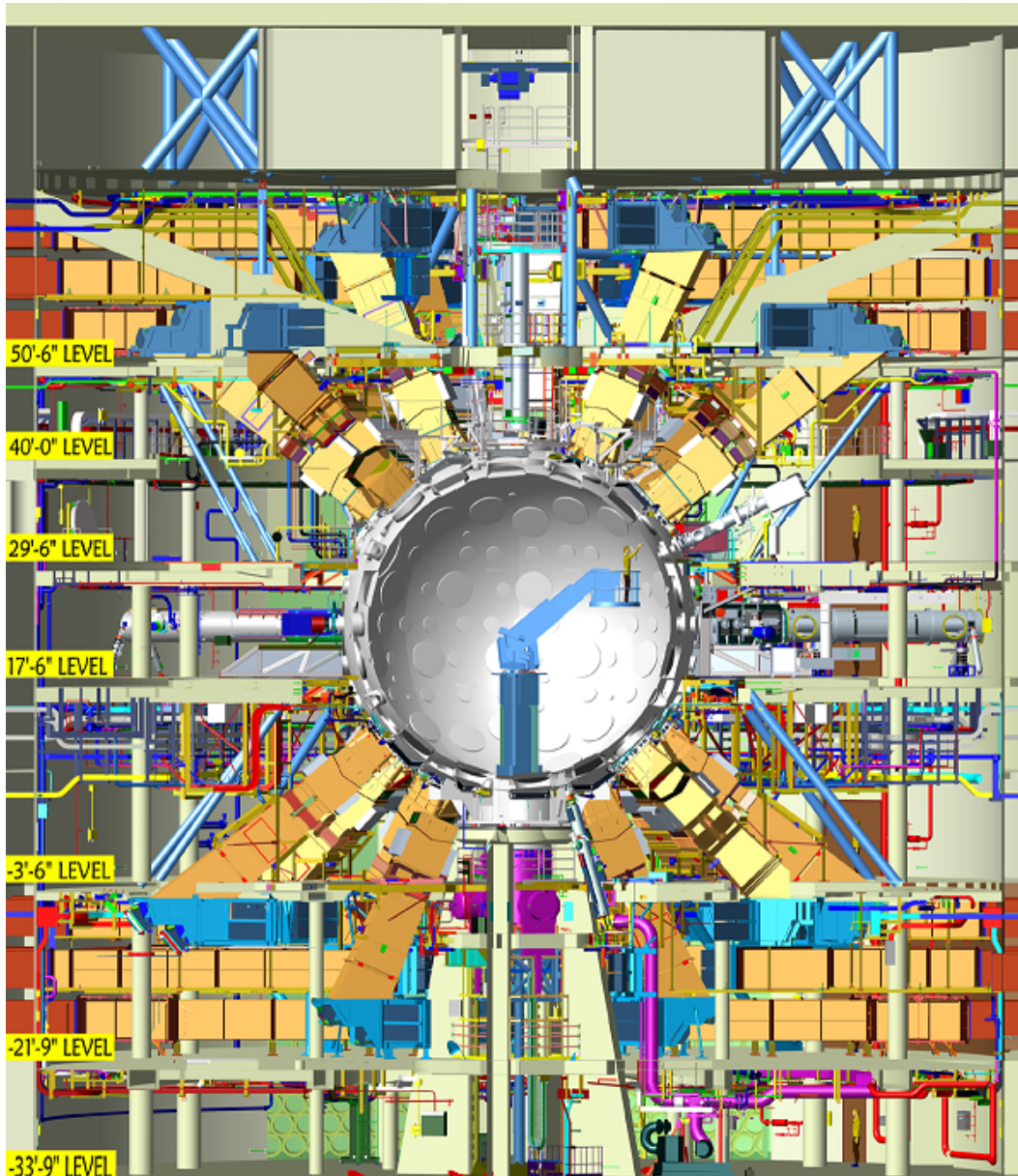
Results w/ 30cm poly: neutrons flux in box with angular distribution

**For 1e16n shot:
4e6n/cm²
incident on
electronics**



- n with $E > 2$ MeV: decrease by 15
- n with $E \approx 14$ MeV: decrease by 30
- Better shielding: add polyethylene on bottom side

Conclusion



- The NIF environment is very complex leading to a large and non trivial radiation background.
- A shield surrounding the electronics is required to lower the neutron background to less than $1e7 \text{ n/cm}^2$.
- Moving electronics to behind the 6 foot-thick target bay wall is the best shield

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